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AUTHOR Hawkridge, David G.
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ABSTRACT

The Open University of Great Britain, using a multimedia, mass media approach offers instruction leading to a university degree. Its Faculty of Science provides instruction in the disciplines of biology, physics, chemistry, and earth science. The philosophy of instruction is anti-specialization, pro-integration; the social impact of science and technology and the social responsibilities of scientists are emphasized. Very soon, 7,000 students will begin the first undergraduate science course to be given, studying in their own homes. They will receive correspondence packages, containing basic course materials; they will have part-time class tutors available to them; they will have access to study centres where they can meet counselors and where they can use the audiovisual facilities--television, radio, film projectors, tape players, record players, and computer terminals. Another learning resource available to students is summer school. Kits for science experiments are sent to the students by mail. Higher-level courses are being planned; for these, laboratory work will be essential, and arrangements for it will probably be made with conventional universities. Applicants to the Open University have had a modal age of 27 years. (MF)

# SCIENCE FOR THE THOUSANDS : THE OPEN UNIVERSITY OF GREAT BRITAIN.

If Lancelot Hogben was able to title his book "Mathematics for the Million" then perhaps the Science Faculty of the Open University of Great Britain can speak of science for the thousands. In a few days' time, some 7,000 students will begin an undergraduate course in science through the Open University. All will be studying in their own homes. In the next half-hour I want to give you a picture of how this remarkable university has come into being and what it hopes to provide in the way of science education.

## Historical Background.

First, we should be aware of the historical background. Universal primary education is only 100 years old in Britain, and the age at which children can legally leave school is still fifteen. At about the age of eleven children in many parts of the country take a selection test on the results of which they are placed in particular kinds of secondary school. The selection system has operated for the past twenty years or so, that is since there has been universal secondary education. One of the effects of the system has been to produce a highly educated elite and a very large poorly educated majority. A very small proportion of the students entering primary school ever reach university. The provision of university places in Great Britain is far below the demand. There are very large numbers of adults in the country who have never had the opportunity to pursue university level studies.

Under these circumstances, it was not surprising that the Labour Party of Great Britain should make plans for remedying the lack of educational opportunity. The Labour Party planned to remedy the lack at the secondary level by introducing comprehensive schools along the lines of American high schools. At the higher education level the Party some seven years ago conceived a University of the Air. This institution was intended to provide university level courses by radio and television for those who had not had a university

education. During the Labour Party's recent term of office much was done to enlarge this conception.

As planning for the new university proceeded it became clear that radio and television alone would not be the best instructional system. Correspondence courses, tutorials, and summer schools were incorporated with radio and television, the result being a highly innovative plan for teaching at a distance. In fact, the Open University is the only one of its kind in the world, as it is to employ a unique combination of media techniques. The change from a purely broadcasting instructional system was accompanied by the new title, The Open University. This title also reflected the philosophy of the Labour Party in opening further educational opportunities. The Open University is therefore open as to its students, as to its methods, and as we shall see, as to the content of its courses.

Thus, the need for such an institution as the Open University in Great Britain is not only supported by the shortage of conventional university places, but also by the existence for many years of the rigid, selective system of examinations in school that have deprived pupils of the chance to attempt university studies. The depth of the public interest in the Open University in Great Britain is considerable. Over 42,000 applications were received for places in the University for its first year of operation.

The Nature of the Institution.

The Open University is an autonomous institution, like all British universities, but it depends heavily on government grants. It is governed by a Council on which prominent academics from many other (conventional) universities sit. But for 1971, the first year of teaching students, the government has provided development costs in excess of $10 million, and the actual teaching of 25,000 students will cost approximately a further $10 million. These costs, incidentally, are far below those for the establishment of a conventional university.

The University is organised into six teaching faculties, namely Arts, Educational Studies, Mathematics, Science, Social Sciences, and Technology. In Arts, Science, Social Sciences

and Technology, several disciplines are represented in each faculty. In the Faculty of Science, for example, there are the disciplines of biology, physics, chemistry and earth science. Besides the six faculties, the academic body of the university also includes the Institute of Educational Technology, a group unique to the Open University, and charged with the design and evaluation of the instructional system. The University has the usual Secretariat and Library, but also has a quite large printing plant and a specialised mail handling unit to deal with the correspondence materials. The Data Processing Unit of the University has a key role to play.

In addition to the teaching body and its support services, the University also has an extensive regional organisation covering the whole of Great Britain. The country is divided up into twelve regions and within them some 250 Study Centres are being established. There are other unusual features about the Open University, when it is compared with other British universities, but some of these features are usual in America. For instance, we have a Director of Publishing, and a Marketing Manager. In many ways the Open University must be seen as a "software" development project. It combines the functions of curriculum development projects such as B.S.C.S. with the capabilities of a large publishing house.

At this point the question might be asked, "Is the University a university?". In legal terms it certainly is. It has a Royal Charter, just like any other British university. In academic terms it has every hope of establishing itself. Its staff have impeccable academic credentials, and are drawn from many different conventional universities. Cambridge University is the one that appears most often on the staff list. Nobody knows exactly what the content and standard of a university course is meant to be, but the Open University is determined to make the standard and content of its courses high. The standard will be set by an intricate system including external examiners drawn from other universities. The content is being established with the help of an academic advisory committee, which again includes academics from other universities. The Open University is determined to be forward looking in its courses and has the advantage of being able to revise them frequently. Some have

suggested that the Open University will be no more than a glorified correspondence college. We refute this accusation by pointing out that the Open University not only depends on a far more intricate and effective instructional system but also provides far more support to its students. We must also point to our unique relationship with the British Broadcasting Corporation, under which the Corporation assists us in the production of television and radio programmes to accompany the correspondence materials, and then broadcasts these programmes.

The Nature of the Courses.

Before the nature of the courses can be understood, some of the philosophy underlying their design must be explained. First it should be understood that the students are mature persons who left school several years ago. The modal age of our applicants is 27 years. Many of them probably attended a poor school, and failed to obtain the entry level for an ordinary university. For some, family pressures may have compelled them to drop out of high school before they were ready to take the university entrance examination. Undoubtedly, the courses must accommodate a wide spectrum of students. We hope to give all students the chance to obtain a degree regardless of their initial performance, by giving them a fresh start.

The second principle underlying our philosophy is our attitude towards specialisation. In Britain as elsewhere there are strong criticisms of the extent of specialisation practised in many universities. Many classes are taught chiefly for the benefit of the top students, to fit them for research projects run by the academic staff. Scant attention is paid to the needs of the majority of students. The Open University has a course structure which is a safeguard against too high a degree of specialisation. A student must choose six courses for a bachelor's degree. Two of these must be foundation courses. These are to be offered in Science, Arts, Social Sciences, Mathematics and Technology. They are multi-disciplinary in nature. This integrated approach is continued in second level courses, too. For example, the second level course on biological causes of behaviour bridges the boundary between biology and psychology, and a course in mechanics is being

created by a team of mathematicians, physicists, and technologists. Only at third and fourth level are the courses more conventional and specialised.

The nature of the courses depends further on the nature of the instructional system.

The Nature of the Instructional System.

(1) First, and most important, the Open University student will receive regularly correspondence packages containing basic course materials. Each package will probably contain four weeks' work, separated into four units. There will be thirty-six units of study in the year for each course. A student may take one or two courses a year.

(2) The second learning resource available to the student is a part-time class tutor. If the student wishes to receive face-to-face assistance he will go to a study centre where he will be able to meet the class tutor.

(3) The study centres represent another learning resource. Besides being staffed by the class tutors they will also be places where students may meet counsellors, whose task it is to deal with any general problems students have in learning from the Open University's instructional system. In the study centres there will also be television and V.H.F. radio sets. In many study centres there will be additional facilities such as 8 mm film projectors, tape players, record players and computer terminals for mathematics students.

(4) The fourth learning resource available to students will be the summer school. Each student will be expected to attend summer schools for up to two weeks in his first year. In these schools he will not only receive additional face-to-face assistance but will also engage in activities important for university level courses and impossible to arrange in the study centres. The summer schools are to be held in conventional universities and will fall in the middle of the Open University academic year which lasts ten months, beginning in January.

(5) As many people know, broadcasts have important roles in the Open University instructional system. Each unit of each course next year will be accompanied by a 25 minute telecast (uninterrupted by advertisements). The telecasts will probably provide

valuable motivation to independent learners who are cut off in many ways from the Open University itself.

(6) The last learning resource in the Open University instructional system is the radio broadcasts, of which there will also be one per unit next year.

The Science Foundation Course.

(7) The Science Foundation Course Team is made up of about a dozen academics drawn from the subject areas, senior B.B.C. producers from television and radio, educational technologists, a scientific editor, and some part-time consultants. This team is responsible for producing thirty-six weeks' work in correspondence materials, television broadcasts and radio broadcasts.

Each unit of the course has to be planned within an overall pattern and philosophy. Deciding upon the basic pattern was a difficult and important task at the beginning of the course team's work. There is such a wide range of content available, and also a wide choice of structure. For example, if physics is thought of as the most basic of the sciences, a case can then be made for dealing with all the physics first, and then building the other disciplines upon the physics. But some students would find the abstract concepts of physics quite the most difficult part of the course. Perhaps a spiral approach, treating all subjects in outline at first, and then teaching them in greater depth, would be a preferable one. Perhaps a unifying theme such as energy would be more helpful.

Each of the four main disciplines was expected to contribute to the course the equivalent of about 30 to 35 conventional university lectures. Within each discipline there were questions of content and structure too. If half the students taking Science Foundation course will be taking it as their "second" foundation course, many of the students taking the thirty lectures worth of biology, say, will not study biology beyond the foundation level. Yet an adequate foundation has to be provided for those who wish to proceed.

After considerable discussion, the course team decided to
(8) use a few units for general introduction and then to start on
(9) the topic of atoms. From the organisation of electrons in

atoms the team was able to proceed to exposition on the periodicity in the chemical and physical properties of the elements. Studies of chemical bonding lead to a survey of
(10) molecular structure, and on to the idea that at a certain degree of complexity macro-molecules achieve an organisation and a set of properties that allow us to label them as living. Next,
(11) the cell and multi-cellular organisms, and the genetic code. This leads to a consideration of evolution by natural selec tion. The varieties of existing organisms are closely related to their
(12) environment. This leads us to study the structure and evolution of the earth.

(13) The course moves from physics to chemistry to biology to earth science and back to physics again. But the boundaries are very hazy. The transition from chemistry to biology is made through bio-chemistry, for example.

(14) Our Science foundation course is also unique in Britain in teaching the subject matter in a social context. We have endeavoured to bring out strongly the relationship between science and society. Our students examine how decisions are made for the setting up of large science projects. As an example, they examine the British decision not to participate in the funding of the European 300 Gev accelerator project. Each student will receive a "decision-making" kit containing material from Government reports, Parliamentary statements, and points of view for and against. From these materials he will be asked to select the factors for use when deciding whether or not to participate in the funding of a project. Pollution will also be studied. The student will be deeply involved in the science of the problem through testing the extent of pollution in his own neighbourhood.

(For those of you who are interested in further details of the Science foundation course, I have copies here of a unit-by-unit outline. I must apologise for not being able to answer directly many questions of content, but I shall be pleased to take your queries back to Britain for reply by members of the Faculty of Science).

The Correspondence Material for the Science Foundation Course.

In the printed text which forms the core of the learning

Home Experiments.

Each science student will be supplied with a kit for home experiments. The kit is to be delivered through the mail, and consists of instruments and material packed in specially designed plastic containers.

The Faculty of Science at the Open University believes that practical work is an essential ingredient of any science course. The home experimental kits represent one of the ways in which this practical experience is to be provided. The main components of the kit are a microscope, a photoelectric colorimeter, a spectroscope, a balance and weights, a stopwatch, tuning forks, spirit burner, and glassware and chemicals. Details of the specially-designed microscope and colorimeter are available on request.

In one experiment, the students will use banana mash to attract fruitflies, which lay eggs in the mash. Adult flies emerge 3 to 4 weeks later. The mash is exposed for different periods of time, and the number of adults emerging is counted. Students will identify the different species too. Their pooled results will provide an informative survey, for which the data will be processed by the University computer and the results reported back to the students on television.

In the experiments concerning pollution, the students will take a series of standard samples of air in order to measure contamination. The readings will be for gases such as carbon dioxide, sulphur dioxide and ozone, and will also be collated and analysed on the university's computer. Seven thousand students a year, supplying a steady stream of data, will offer such bodies as the (British) Air Pollution Laboratory a far more detailed "pollution map" than was possible before.

Other experiments involve studying the formation of coacervate drops, flame spectra, and so on. All can be performed by the student at home.

The Television and Radio Broadcasts.

Of course, many people in America have heard of the B.B.C. Few may realise, however, that the British Broadcasting Corporation is an autonomous institution, just as the Open University is. The relationship which has been built up between these two institutions is a remarkable one. The B.B.C.

experience for the Open University student, variations in the background of students are dealt with by structuring the text into three "channels". The middle channel is the main text. The student is tested frequently regarding his previous background knowledge. Where necessary, the student goes to the lower channel. Revision packages in this channel help him to rejoin the main channel. Some students may find some of the work too easy in the main text. They can then move into the upper channel, where the material of the main text is enriched. The material in the upper channel is optional, but the student who intends to proceed to further courses in say chemistry should take as much as possible of the upper channel of the chemistry units. Thus we shall be providing individualised routes through the learning material in the correspondence packages. The correspondence texts have more in common with American standard text books than English ones. At places where the student should be able to deduce the next step, the text is broken by a question, maybe once or twice a page. Numerical examples and experiments are included to stimulate the student and urge him to participate. All units will also have lists of clearly stated objectives so that the student knows exactly what he is expected to be able to do as a result of reading the unit.

The correspondence package will also include some self-assessment tests, intended to help the student to discover whether he can reach the objectives. Also provided is a conceptual map, a diagram showing the relationships of different concepts of the unit to each other. Other items include a glossary, notes for radio and television programmes, and instructions for experiments the student is expected to perform.

Also contained in the correspondence package will be the assignment. Each week there will be a computer-marked assignment. Many of the computer-marked assignments will be of the usual multiple-choice type, but the Open University is also devising computer-marked assignments that will assess the students' ability to reach some of the higher levels in Bloom's "Taxonomy of Educational Objectives". Once a month the student will complete a tutor-marked assessment test. These will generally take the form of short essays, problems to be solved and reports on experimental work.

directors are members of the course teams. They may, and do, comment on the content of the course materials. In the Science foundation course team, the directors are science graduates. The members of the course team, including the directors, are determined to prepare materials that will teach the students. They have no regard for audience ratings, in spite of the fact that some two million people may watch Open University programmes in addition to the 7,000 foundation course science students. The same is true for the radio components of the courses.

In fact, the programmes that are being produced for television are not even good self-contained films. Instead they are so closely integrated with the other components of the Open University instructional system that they will be somewhat incomprehensible to people who are not students.

For example, the third television programme starts with a demonstration of the principle of momentum conservation using an air track. The second topic dealt with is the measurement of the speed of light. At the Royal Institution of London there already exists some equipment that can be readily adapted for this purpose, and the film was shot there. A series of very short pulses of light were sent across a room and reflected back to a photomultiplier tube. The intensity profiles of the sparks were shown on an oscilloscope screen. The time taken for the return journey was estimated from their displacement along the time base. The signals were also fed into a computer, in which the profiles of the successive sparks were averaged. The correspondence text contains the raw computer data and the distance of the light paths. After the programme, students were asked to calculate the speed of light to an accuracy of about 2%, as part of their assessment for the week. The last part of the same programme deals with the question of why our ideas on simultaneity have to be revised in view of special relativity theory, using a four minute animated film to analyse the problem. All this within one twenty-five minute programme. The student needs to be well prepared if he is to obtain maximum benefit. The programme seeks to involve the student, and is quite different from the average instructional film or television programme.

On radio, a more relaxed "tutorial" atmosphere is being

adopted. Some of the programmes have involved the bringing together of groups of experts to discuss the technological, social and political aspects of a particular subject. Sometimes the historical context of the week's material is set. Other programmes are being reserved for last-minute remedial help. In some cases they may be used for updating the course when there have been rapid developments and changes in contemporary science. A few programmes may be used to draw the students' attention to relationships between the concepts or methods of one part of science and those of another.

Both the television and radio broadcasts will have the important psychological effect of giving the students the feeling of belonging to a community of learners.

The Summer Schools in Science.

The summer schools in science will be very largely laboratory based. There will be two types of laboratory experience. First, there will be a number of open-ended project experiments. These will have some objectives that can be reached by everyone, but will offer plenty of scope to the more experienced or able student. In parallel with the project experiments, the student will work on a number of experiments selected from the ready-made stock of the host university. These will give the student a chance to manipulate standard laboratory instruments and more sophisticated devices. The combination of the compulsory projects and the selected optional items will offer each student what he needs. The summer schools will also offer tutorials, films, reading in libraries, and lectures given by the Faculty of Science staff touring the schools.

Tutorial Classes in Science.

For most science students, there will be a fortnightly tutorial session in a study centre. In areas of dense population there should be no great difficulty in arranging this. In country areas the problems may be considerable. Attendance at study centres is not obligatory for the students.

The week by week activities have not been specified for

the tutor will arrange for his students to view the television programme or listen to the radio broadcasts as a group. The broadcasts would be followed by a discussion in which students would learn not only from the tutor but also from each other by going over the material that had been taught.

The Future.

Planning for second-level courses is in its early stages, but some details are available on request. Laboratory work will become increasingly essential and will probably be arranged through further collaboration with conventional universities, to make maximum use of their plant. The same is likely to be true at third and fourth levels. (Fourth level represents graduate studies.) At second level, the courses are being devised to permit students a very wide range of choice. Half and quarter credits can be combined to provide a student with university studies that are highly apposite to his vocational interests. Such a system is new in England, although it is common in the U.S.

The Open University has a unique multi-media system for instruction. The Faculty of Science is determined to use the system to great effect to teach science to the thousands.

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